AGGRESSIVENESS AND PHYSIOLOGICAL SPECIALIZATION OF *Septoria tritici* Rob. ISOLATES

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ABSTRACT: Pathogenicity tests verifying the behavior of *Septoria tritici* isolates should be considered as a priority in the selection of resistant wheat materials to this pathogen, since the aggressiveness of each isolate can vary significantly, causing problems in the evaluation and selection of resistant genotypes. The objective of this work was to determine whether physiologic specialization exists among Argentinean and American *Septoria tritici* isolates, through the analysis of their pathogenicity on cultivars and lines of bread wheat (*Triticum aestivum* L.). The experiments were carried out in Castelar-Argentina and in Davis-USA. In Castelar, a split plot design (n = 4) was used. The cultivars or lines were randomized in the plots and the isolates in the subplots. Each subplot consisted of three plants belonging to a cultivar or line. In Davis, a strip split plot design (n = 6) was used. A pot containing three plants of each cultivar or line constituted the experimental plots. In both sites, the inoculation was made at the flag leaf phenological stage through foliar aspersion of a conidial suspension adjusted to 10^6-10^8 conidia mL^{-1}. Evaluations were made by recording the leaf area covered with pycnidia (LACP) at the flag leaf stage with the use of rating scales. Differences ($P \leq 0.0001$) in LACP were detected among cultivars or lines. Isolate effects and the interaction cultivar × isolate were significant ($P \leq 0.0001$). Variations in aggressiveness and virulence were found among the isolates, indicating the presence of horizontal and vertical resistance in the host cultivars.
Key words: *Mycosphaerella graminicola*, *Triticum aestivum*, leaf blotch, vertical resistance, horizontal resistance

AGRESSIVIDADE E ESPECIALIZAÇÃO FISIOLÓGICA EM ISOLADOS DE *Septoria tritici* Rob.

RESUMO: Testes de patogenicidade destinados a verificar o comportamento de isolados de *Septoria tritici* frente a genótipos de trigo (*Triticum aestivum* L.) devem ser considerados como uma prioridade na seleção de materiais resistentes, já que a agressividade de cada isolado pode variar significativamente em função do hospedeiro. O objetivo do presente trabalho foi determinar se existe variação da agressividade ou especialização fisiológica em isolados de *Septoria tritici* Rob. originários de Argentina e EUA em cultivares e linhagens de trigo. Os experimentos foram estabelecidos em Castelar-Argentina e em Davis-EUA. Na primeira localidade utilizou-se um delineamento experimental em parcelas divididas com quatro repetições, onde as cultivares foram aleatorizadas nas parcelas e os isolados nas subparcelas. Cada subparcela foi composta por três plantas pertencentes a um determinado cultivar. Na segunda localidade, foi adotado um delineamento em blocos casualizados e arranjo em faixas, com seis repetições, onde as parcelas experimentais foram constituídas por um vaso contendo três plantas de cada cultivar. A inoculação foi feita no estádio fenológico de folha bandeira em ambas localidades com uma suspensão de conídios ajustada a uma concentração de 10^6-10^8 esporos mL^{-1}, empregando a técnica de inoculação por aspersão foliar. As avaliações foram feitas registrando-se a área foliar coberta por picnídios (AFCP) no estádio de folha bandeira com auxílio de escalas de notas. Em ambas localidades foram detectadas diferenças significativas ($P \leq 0{,}0001$) em AFCP entre cultivares. Foram também detectados efeitos significativos de isolados e da interação cultivares x isolados ($P \leq 0{,}0001$). Foram detectadas variações na agressividade e virulência dos isolados sugerindo a presença de resistência horizontal e vertical no material vegetal testado. Testes de patogenicidade destinados a verificar o comportamento de isolados de *Septoria tritici* devem ser considerados como uma prioridade na seleção de materiais de trigo resistentes a este patógeno.
Palavras-chave: *Mycosphaerella graminicola*, *Triticum aestivum*, mancha foliar, resistência vertical, resistência horizontal

INTRODUCTION

Plants present two basic types of resistance to pathogens: vertical and horizontal resistance. Both types of resistance are defined in terms of two variables: the host and the pathogen. In this system, host resistance to a disease can exist only under two alternative forms. The variation observed in the host determines the presence of horizontal resistance. The differential interaction between both the pathogen and the host determines the existence of vertical resistance. Aggressiveness and virulence are terms utilized to describe the pathogen's behavior in the presence of horizontal and vertical resistance, respectively. Both types can coexist, i.e., resistance in a host could be the result of a combination between vertical and horizontal resistance (Vanderplank, 1984).

Vertical resistance is also known in plant breeding as "specific", and is determined by one or a few genes that impart complete resistance to a certain pathogen. This type of resistance is also known as "short-term" resistance, and also known as qualitative, monogenic, or strain-specific resistance (Gair et al., 1987).

Horizontal resistance, in turn, is usually associated with several genes and imparts an incomplete type of resistance; the host is attacked by the pathogen in a higher or lower degree, depending on the number and type of genes involved in the resistance. This type of resistance is also known as general resistance, field resistance, non-specific, quantitative, or polygenic resistance (Jacobs & Broers, 1989; McIntosh, 1998; Robert et al., 2000).

Both types of resistance have been found in wheat. Narvaez & Caldwell (1954), Rillo & Caldwell (1966), Wilson (1979), Lee & Gough (1984), Rosielle & Brown (1979), Potts & Hughes (1987), and Somasco et al. (1996), analyzing different wheat cultivars, found qualitative resistance, where one to three major genes would be responsible for the resistance in the studied cultivars. On the other hand, Eyal (1981), Jlibene et al. (1994), and Simon & Cordo (1998), reported the presence of polygenic or quantitative resistance with the predominance of additive genetic effects.

The presence of the perfect form of the fungus *Mycosphaerella graminicola* (Fuckel) Schroeter has been reported in many parts of the world, such as New Zealand (Sanderson, 1972), Australia (Brown et al., 1978), Chile (Madariaga, 1986), England (Scott et al., 1988), Brazil (Mehta, 1989), the Netherlands (Shaw & Royle, 1989), the USA - California and Oregon (Madariaga et al., 1989; Ahmed et al., 1995), Germany (Vereet et al., 1990), and France (Halama, 1996). The presence of the sexual form of the pathogen provides an additional mechanism by which its genetic variability can be increased (Ahmed et al., 1995). Evidences of differential interactions between *Septoria tritici* isolates and wheat cultivars were described in Israel, Morocco and the USA, suggesting the physiological specialization of the pathogen (Eyal et al., 1973; King et al., 1983; Saadaoui, 1987).

The objective of this work was to determine whether variations exist in the aggressiveness or physiological specialization of *Septoria tritici* Rob. isolates from Argentina and the USA, by means of inoculations on wheat cultivars and lines.

MATERIAL AND METHODS

Isolates

Experiment 1: Castelar-Argentina

Thirty *Septoria tritici* isolates were tested to analyze their pathogenicity on 11 wheat cultivars. The isolates were obtained from locations within wheat-producing regions in the Province of Buenos Aires (Table 1).

Experiment 2: Davis-USA

The isolates included in this experiment were USA 00005 and CA 30. The first was isolated from line UC 1036 in Colusa, CA. The second isolate (CA 30) was ob-

Table 1 - Cultivars and collection locations of the isolates utilized in pathogenicity tests in Castelar, Argentina.

Septoria tritici isolates			
Isolate	Cultivar source	Geographical source*	Year
1:I7	Buck ñanque	Balcarce	1998
2:I6	Buck ñanque	Balcarce	1998
3:I122	Klein cacique	Barrow	1998
4:I76G	Prointa Federal	Balcarce	1998
5:I77G	ProintaFederal	Balcarce	1998
6:I27	Buck arrayán	Balcarce	1998
7:I42E	Prointa oasis	Balcarce	1998
8:I89	Klein cacique	Barrow	1998
9:I31	Prointa oasis	Balcarce	1998
10:I78G	Prointa federal	Balcarce	1998
11:I16	Buck ñanque	Balcarce	1998
12:IA1	Klein cacique	LosHornos	1999
13:I109	Klein cacique	Barrow	1998
14:I7ñv	Buck ñanque	Balcarce	1998
15:IR7	Klein cacique	Los Hornos	1999
16:IR2	Klein cacique	Los Hornos	1999
17:I74	Prointa federal	Balcarce	1998
18:I88	Klein cacique	Alberti	1998
19:I44	Buck ñanque	Balcarce	1998
20:I1.4	Klein cacique	Los Hornos	1999
21:I108	Klein cacique	Barrow	1998
22:I2P	Prointa isla verde	Pergamino	1998
23:I13	Buck ñanque	Balcarce	1998
24:I26	Buck arrayán	Balcarce	1998
25:I12	Buck ñanque	Balcarce	1998
26:IA3	Klein cacique	Los Hornos	1999
27:I30	Buck arrayán	Balcarce	1998
28:I65G	Prointa federal	Balcarce	1998
29:I100	Klein cacique	Balcarce	1998
30:I14	Buck ñanque	Balcarce	1998

*Province of Buenos Aires, Argentina.

tained from wheat cultivars in the experimental area of the Department of Agronomy and Range Science, Davis, CA. Isolate USA 00005 was chosen since it has high aggressiveness and infects Tadinia (80% of the leaf area necrotic and covered with pycnidia), in addition to other resistant cultivars such as Veranopolis, Frontana, IAS 20, and Bulgaria 88 (Goodwin, personal communication). The objective of this experiment was to verify the aggressiveness of isolate USA 00005 in relation to isolate CA 30, to which Tadinia, Veranopolis, Frontana, IAS 20, and Bulgaria 88 are resistant, and to determine whether this isolate can be considered as a physiological variant of *Septoria tritici*.

Plant material

Experiment 1: Castelar-Argentina

The 11 different cultivars utilized in this study were selected because of their reaction to *Septoria tritici* in previous assays; three of them are resistant, four are susceptible, three are moderately resistant and one is moderately susceptible (Somasco et al., 1996; Simon & Cordo, 1998). The characterization of these cultivars, including their source and reaction to *Septoria tritici*, are presented in Table 2.

Experiment 2: Davis-USA

In this study, 20 different cultivars and 10 CIMMYT lines resistant to *Septoria tritici* were utilized. The cultivars were selected because of their reaction to *Septoria tritici* in previous assays; the group consisted of resistant, moderately resistant, moderately susceptible, and susceptible cultivars and/or lines (Somasco et al., 1996; Simon & Cordo, 1998) (Table 3).

Table 2 - Main characteristics of cultivars utilized in pathogenicity tests in Castelar, Argentina.

Cultivar	Source	Reaction to *Septoria tritici*
Tadinia	UCD	R
Yecora rojo	UCD	S
UC 554	UCD	MR
INIA 66R	INIA	MR-MS
UC 1041	UCD	R
Cooperación Maipun	Queaca	R
Cooperación Calquin	Queaca	S
Marcos Juarez INTA	INTA	S
HLP*	INTA	MR
Leones INTA	INTA	S
Baguette 12	Nidera	MS

R: resistant; S: susceptible; MR: Moderately resistant; MS: Moderately susceptible. UCD: *University of California*-Davis, USA. Queaca: *Química Estrella-Asociación de Cooperativas Argentinas*, Argentina. INTA: *Instituto Nacional de Tecnología Agropecuaria*, Argentina. Nidera: *Private company*, Argentina. INIA: *Instituto Nacional de Investigación Agropecuaria*, Chile.

Table 3 - Main characteristics of cultivars utilized in the pathogenicity tests in Davis, CA, USA.

Cultivar/Line	Source	Reaction to *Septoria tritici*
CIMMYT 1	CYMMYT	R
CIMMYT 2	CYMMYT	R
CIMMYT 3	CYMMYT	R
CIMMYT 4	CYMMYT	R
CIMMYT 5	CYMMYT	R
CIMMYT 6	CYMMYT	R
CIMMYT 7	CYMMYT	R
CIMMYT 8	CYMMYT	R
CIMMYT 9	CYMMYT	R
CIMMYT 10	CYMMYT	R
Israel 493	UCD	R
Bulgaria 88	UCD	R
Veranopolis	UCD	R
Tadinia	UCD	R
WR 33 TA 5056	UCD	R
Chinese Spring S. 7D	UCD	R
IAS 20	UCD	R
Marcos Juarez INTA	INTA	S
Leones INTA	INTA	S
Don Ernesto INTA	INTA	R
Prointa Isla verde	INTA	S
Klein Toledo	INTA	R
Klein Atlas	INTA	S
Coop. Maipun	Queaca	R
Coop. Calquin	Queaca	S
Synthetic 43	UCD	R
Opata 85	UCD	S
UC 554	UCD	MR
INIA 66R	UCD	MR-MS
Yecora rojo	UCD	S

R: resistant; S: susceptible; MR: Moderately resistant; MS: Moderately susceptible. CIMMYT: *Centro Internacional de Mejoramiento de Maíz y Trigo- México*; UCD: *University of California*-Davis, USA; Queaca: *Química Estrella-Asociación de Cooperativas Argentinas*, Argentina; INTA: *Instituto Nacional de Tecnología Agropecuaria*, Argentina.

Evaluation of resistance

Experiment 1: Castelar-Argentina

An experimental design in split plots (n = 4) was adopted, in which cultivars were randomized in the plots and isolates were randomized in the subplots. Each subplot consisted of three plants belonging to a given cultivar. Cultivars were sown in May, 2000. The inoculation was made 70 days after plant emergence (DAE), corresponding to the flag leaf phenological stage. The subplots of each cultivar were inoculated with a spore suspension of the corresponding *Septoria tritici* isolate, using the leaf sprinkling inoculation technique (Dhingra & Sinclair, 1986; Eyal et al., 1987). The inoculum concentration was 10^6-10^8 spores mL^{-1}. After inoculation, a humid chamber (36 h) was prepared by covering the blocks with plastic film.

Thirty days after inoculation, plants were evaluated and the leaf area covered with pycnidia (LACP) was recorded, according to Eyal & Brown's scale (1976).

Experiment 2: Davis-USA.

A strip split plot experimental design (n = 6) was utilized, where the isolates were randomly allocated to each strip. Each plot consisted of a pot containing three plants belonging to a given cultivar. Cultivars were sown in December, 2000. The experiment was conducted in controlled environment. The inoculation was made at 70 DAE (flag leaf phenological stage). The inoculation technique and the evaluation of severity of the disease followed the scheme detailed for Experiment 1.

Statistical analysis

Analyses of variance and mean comparison tests (Tukey) were conducted for the LACP character (proc GLM). The SAS version 8.0 statistical software (SAS, 1999) was used to analyze the data.

RESULTS AND DISCUSSION

Experiment 1: Castelar-Argentina

Differences ($P \leq 0.0001$) were detected among cultivars and isolates. The cultivar × isolate interaction was also significant ($P \leq 0.0001$). Cultivars Yecora rojo, Leones INTA, Cooperación Calquin and Marcos Juarez INTA, behaved as susceptible; Tadinia, Cooperación Maipun, UC 1041, and HLP behaved as resistant, while Baguette 12, UC 554, and INIA 66R showed intermediate behavior to all isolates tested (Table 4).

The isolates showed differences in their aggressiveness for the 11 cultivars. Isolates I89, I42E, I14, IR2, I6, I109, I122, and I31 were the most aggressive. Isolates I109, I122, I31, I26, I76G, I77G, I30, I44, I2P, I100, I108, I13, IA3, I7, I16, I88, and I7ñv exhibited intermediate aggressiveness. Finally, isolates I74, IR7, I65G, I27, I1.4, I12, I78G, and IA1 were the least aggressive (Table 5).

The genotypes of the isolates interacted differentially with the genotypes of the host cultivars, indicating the presence of vertical resistance (Figure 1). The differential interaction can be observed between isolates I27 and I31, and cultivars 3 and 4; I27 and I6 and cultivars 4 and 5; I6 and I31 and cultivars 5 and 6, and finally between isolates I89 and I42 and cultivars 6 and 7.

This differential interaction can be interpreted from two standpoints. From the pathogen's standpoint (isolate), its physiological specialization, by means of the pathogenicity process selection, determined the existence of host-specific virulence genes. The presence of the perfect form of the fungus in many parts of the world is a

Table 4 - Tukey test for leaf area covered with pycnidia (LACP) involving the eleven cultivars.

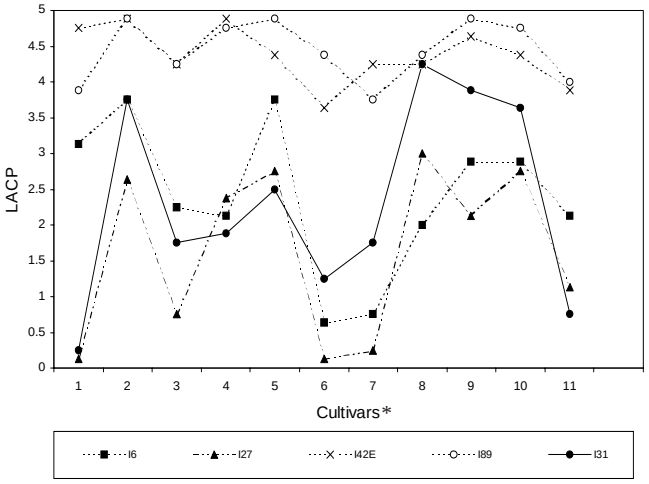
Cultivar	LACP
Yecora rojo	3.29 a
Leones INTA	3.12 ab
Cooperación Calquin	3.05 b
Marcos Juarez INTA	2.97 b
Baguette 12	2.73 c
INIA 66R	1.74 d
UC 554	1.54 e
HLP	1.35 ef
UC 1041	1.27 fg
Cooperación Maipun	1.10 gh
Tadinia	1.06 h

LACP: Eyal & Brown Scale: (0-5) (0= 0%, 1= 12%, 2= 25%, 3= 50%, 4= 75%, 5= 87%).
Means followed by a common letter are not different by Tukey test ($\alpha = 0.01$).

Table 5 - Tukey test for leaf area covered with pycnidia (LACP), involving thirty *S. tritici* isolates inoculated on eleven cultivars.

Isolate	LACP
I89	4.43 a
I42E	4.39 a
I14	2.81 b
IR2	2.42 c
I6	2.41 c
I109	2.38 c
I122	2.38 c
I31	2.32 c
I26	2.22 cd
I76G	2.21 cde
I77G	2.08 def
I30	2.01 defg
I44	1.98 efgh
I2P	1.97 fgh
I100	1.97 fgh
I108	1.89 fghi
I13	1.80 ghij
IA3	1.78 ghij
I7	1.78 ghij
I16	1.75 hijk
I88	1.73 ijkl
I7ñv	1.73 ijkl
IA1	1.71 ijklm
I78G	1.71 ijklm
I12	1.67 ijklm
I1.4	1.67 ijklm
I27	1.63 jklm
I65G	1.53 klm
IR7	1.51 lm
I74	1.48 m

LACP: Eyal & Brown Scale: (0-5) (0= 0%, 1= 12%, 2= 25%, 3= 50%, 4= 75%, 5= 87%).
Means followed by a common letter do not differ by Tukey test ($\alpha = 0.01$).



*: 1: Tadinia, 2: Yecora rojo, 3: UC 554, 4: Inia 66R, 5: UC 1041, 6: Cooperación Maipun,
7: Cooperación Calquin, 8:Marcos Juárez INTA, 9:HLP, 10: Leones INTA and 11: Baguette 12.

Figure 1 - Leaf area covered with pycnidia (LACP) resulting from the interaction between five *Septoria tritici* isolates and eleven wheat cultivars.

determinant factor in its evolutionary process, through the generation of variants adapted to certain host cultivars.

From the host's standpoint (cultivar), the interaction with certain isolates in a given geographical area allowed the manifestation of resistance genes specific for those isolates, which were perpetuated through the process of artificial selection aimed at the formation of new cultivars. In agreement with these results, evidences of differential interactions between *Septoria tritici* isolates and wheat cultivars have been found in Israel, Morocco, United States and England, suggesting that the physiological specialization of the pathogen has occurred (Eyal et al., 1973; King et al., 1983; Saadaoui, 1987; Ahmed et al., 1995; Kema et al., 1996a, 1996b; Brown et al., 2001).

The horizontal resistance can be explained based on the aggressiveness manifested by isolates I 42E and I89. These two isolates are characterized by being highly aggressive, attacking the resistant cultivars and inducing greater severity of the disease in the susceptible cultivars. This can be seen in Table 6, where a comparison is presented between the LACP for isolates I42E and I89 and the mean LACP for the remaining 28 isolates.

Table 6 - Comparison between the severity of LACP obtained for isolates I42E and I89 and the mean severity obtained for the remaining 28 isolates.

	Isolate I42E	Isolate I89	28 isolates
Cultivar	LACP	LACP	LACP
1: Tadinia	4.75	3.88	0.83
2: Yecora rojo	4.88	4.88	3.17
3: UC 554	4.25	4.25	1.34
4: INIA 66R	4.88	4.75	1.52
5: Coop. Calquin	4.38	4.88	2.94
6: Coop. Maipun	3.63	4.38	0.90
7: HLP	4.25	3.75	1.17
8: Marcos Juarez INTA	4.25	4.38	2.87
9: Leones INTA	4.63	4.88	3.00
10: Baguette 12	4.36	4.75	2.60
11: UC 1041	3.86	4.00	1.08

LACP: Eyal & Brown Scale: (0-5) (0= 0%, 1= 12%, 2= 25%, 3= 50%, 4= 75%, 5= 87%).

Experiment 2: Davis-USA

Differences ($P \leq 0.0001$) were detected in the analysis of variance for LACP between isolates and between cultivars. The isolate × cultivar interaction was also significant ($P \leq 0.0001$).

Cultivars Opata 85, Inia 66R, Yecora rojo, Cooperación Calquin, Prointa Isla Green, and Klein Atlas behaved as susceptible; CYMMYT 2, WR 33 TA 5056, Synthetic 43, Israel 493, UC 554, Klein Toledo, CIMMYT 3, Don Ernesto INTA, Chinese Spring S. 7D, CIMMYT 6, Cooperación Maipun, and CIMMYT 10 behaved as resistant; CIMMYT 7, CIMMYT 5, Bulgaria 88, CIMMYT 4, Leones INTA, CIMMYT 9, CIMMYT 8, Veranopolis, Tadinia, CIMMYT 1, Marcos Juarez INTA, and IAS 20 manifested an intermediate behavior in relation to isolates USA 00005 and CA 30 (Table 7).

The USA 00005 and CA 30 isolates showed differences ($P \leq 0.0001$) in relation to the mean LACP when inoculated on the thirty wheat cultivars (USA 00005 LACP = 2.04 and CA 30 LACP = 1.23). Isolate USA 00005 was, on average, more aggressive than isolate CA30.

Isolate USA 00005 caused greater severity of the disease in most cultivars evaluated (Figure 2). This type of interaction works under the assumption that the horizontal type of resistance occurs in the cultivars analized. However, the presence of cultivars exhibiting an opposite behavior, i.e., showing greater susceptibility to isolate CA 30 (cultivars 18, 19, and 30), allowed to observe the presence of a differential interaction between isolates and host cultivars, a fact that provides evidence of the presence of vertical resistance in the population of cultivars under analysis.

In addition, in the inoculation with isolate USA 00005 it was possible to observe that a group of cultivars resistant to isolate CA 30 - Tadinia, Bulgaria 88, Veranopolis, and IAS 20 - behaved as susceptible to this isolate, manifesting high severity of the disease, as evidenced by the LACP values (Figure 2). The occurrence of differential interactions between genotypes from hosts and from isolates suggest the presence of a gene-to-gene interaction. The USA 00005 isolate can be considered as a variant of *Septoria tritici* that carries virulence genes that determine the ability to infect cultivars resistant to the CA 30 *Septoria tritici* isolate (Figure 2). The USA

00005 isolate proved to be virulent on cultivars that carry the *Stb*1 (Bulgaria 88), *Stb*2 (Veranopolis), and *Stb*4 (Tadinia) resistance genes.

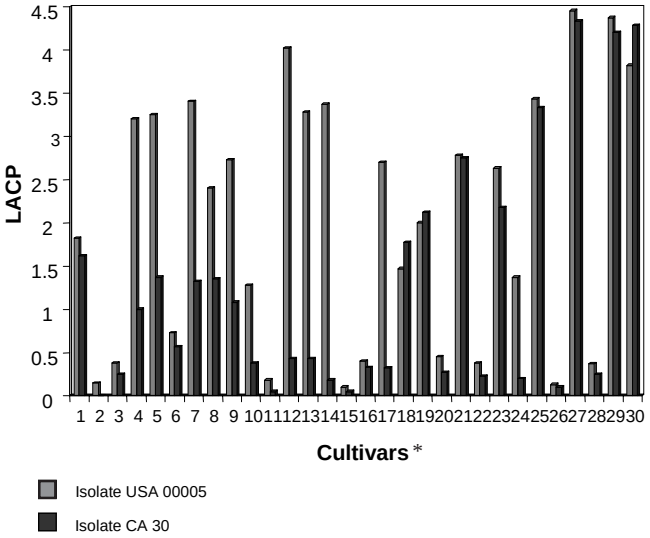
Kema et al. (1996b) and Kema & Van Silfhout (1997), also found differential interactions between wheat genotypes and *Septoria tritici* isolates. Gene-to-gene interactions between wheat genotypes and *Septoria tritici* isolates, suggesting the presence of a strain-specific type of resistance, were reported by McCartney et al. (2002) and Brading et al. (2002).

Ahmed et al. (1995), studying *Septoria tritici* isolates from Oregon, California, and Texas, demonstrated the existence of a specific isolate-environment (location) adaptation. This specific adaptation and the high genetic variability that exists within populations of the pathogen (Mc Donald & Martinez, 1990) would be the factors that determine the selection of host-specific and locally-adapted virulent strains.

Table 7 - Tukey test for Leaf area with lesions, involving the thirty cultivars inoculated with isolates USA 00005 and CA 30.

Cultivar	LACP
Opata 85	4.39 a
Inia 66R	4.28 a
Yecora rojo	4.05 b
Coop. Calquin	3.38 b
Prointa Isla verde	2.77 c
Klein Atlas	2.40 d
CIMMYT 7	2.36 ef
CIMMYT 5	2.31 ef
Bulgaria 88	2.23 ef
CIMMYT 4	2.10 efg
Leones INTA	2.06 fgh
CIMMYT 9	1.91 ghi
CIMMYT 8	1.88 ghi
Veranopolis	1.86 ghi
Tadinia	1.78 hij
CIMMYT 1	1.72 ij
Marcos Juarez INTA	1.62 ij
IAS 20	1.51 j
CIMMYT 10	0.83 k
Coop. Maipun	0.78 k
CIMMYT 6	0.65 kl
Chinese Spring S. 7D	0.37 lm
Don Ernesto INTA	0.36 lm
CIMMYT 3	0.32 lm
Klein Toledo	0.31 m
UC 554	0.31 m
Israel 493	0.12 m
Synthetic 43	0.12 m
WR 33 TA 5056	0.08 m
CIMMYT 2	0.08 m

LACP: Eyal & Brown Scale: (0-5) (0= 0%, 1= 12%, 2= 25%, 3= 50%, 4= 75%, 5= 87%).
Means followed by a common letter do not differ by Tukey test ($\alpha = 0.01$).



*1: CIMMYT 1, 2: CIMMYT 2, 3: CIMMYT 3, 4: CIMMYT 4, 5: CIMMYT 5, 6: CIMMYT 7: CIMMYT 7, 8: CIMMYT 8, 9: CIMMYT 9, 10: CIMMYT 10, 11: Israel 493, 12: Bulgaria 88, 13: Veranopolis, 14: Tadinia, 15: WR 33 TA 5056, 16: Chinese Spring S. 7D, 17: IAS 20, 18: Marcos Juarez INTA, 19: Leones INTA, 20: Don Ernesto INTA, 21: Prointa Isla Verde, 22: Klein Toledo, 23: Klein Atlas, 24: Cooperación Maipun, 25: Cooperación Calquin, 26: Synthetic 43, 27: Opata 85, 28: UC 554, 29: Inia 66R and 30: Yecora rojo.

Figure 2 - Leaf area covered with pycnidia (LACP) of thirty wheat cultivars inoculated with isolates USA 00005 and CA 30, respectively.

In the case of pathogens that have a high genetic variability such as *Septoria tritici*, the presence of new cultivars that carry different resistance gene arrays determines, in turn, the selection of new virulence factors in the pathogen. As a consequence, new strains of the pathogen will appear, bearing the ability to break the resistance of the new cultivar. These new strains quickly disseminate at the same pace in which the new cultivars are extensively planted, so that in a short period of time (two or three commercial planting seasons) they become susceptible. When this happens, the cultivars must be replaced with others carrying new resistance genes (Gair et al., 1987).

The complexity of the interactions found in the *Septoria tritici*-wheat pathosystem requires breeders to have a profound knowledge about them when a breeding program aimed at achieving resistance to the disease is to be established, whatever the approach that is taken. The pathogenicity tests designed to verify the behavior of *Septoria tritici* isolates must be considered as a priority in the selection of wheat materials resistant to this pathogen, since the aggressiveness of each isolate can vary significantly, causing problems in the evaluation and selection of resistant genotypes. The selection of a quantitative-type approach for a breeding program targeted at resistance to *Septoria tritici* would be more convenient because, in addition to allowing the difficulties imposed

by the specific isolate-cultivar interactions to be overcome, it would also contribute to prevent the emergence of strains conditioned by the use of cultivars with vertical resistance.

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